

SYMPOSIUM ON FOOD PROBLEMS IN RELATION TO THE WAR.

I.

PHYSIOLOGICAL EFFECTS OF A PROLONGED REDUC- TION IN DIET ON TWENTY-FIVE MEN.¹

BY FRANCIS G. BENEDICT.

(Read April 20, 1918.)

I am privileged this afternoon to discuss the subject of food conservation from a point of view based upon an extensive research made in conjunction with Drs. Walter R. Miles, Paul Roth, and H. Monmouth Smith. The details will shortly be published in a monograph by the Carnegie Institution of Washington.

It is perhaps remarkable that with all the current discussion regarding food conservation so little emphasis has been laid upon the possibility of conserving food by reducing the diet. When one recalls the agitation of enthusiasts for reduced diets during the past thirty years and recognizes the fact that all special, pet theories can, at this psychological moment, obtain a better hearing than at any previous time, it is surprising that the advocates of reduced diet have made so little progress and, indeed, have apparently ceased their propaganda.

The popular conception that we eat too much is usually quantitatively expressed by the statement that we eat "twice as much as we ought." The Nutrition Laboratory has for years been endeavoring to discover if there exist any special groups of individuals who live regularly upon a diet that would be commensurately low. For this purpose it was assumed that the minimum or basal metabolism must be taken as the index of food requirement. Differences in muscular activity are so great that no two individuals can be

¹ From the Nutrition Laboratory of the Carnegie Institution of Washington, Boston, Massachusetts.

compared save on an absolute quiescent, resting basis. After the metabolism of 200 or more individuals had been carefully measured, it was seen that, although we were dealing with people of varying ages, dietetic habits, and supposedly very low metabolism, no such individuals were easily recognized in our measurements. It would thus appear, offhand, that if there are no individuals other than pathological, which present abnormally low basal metabolism and if the law of conservation of energy in the human body obtains, as we know it does, then there is no *a priori* reason for expecting that a reduced diet can be permanently adhered to. A reduction in diet will simply mean that body reserves will be drawn upon until death from starvation occurs.

About a year ago I had the privilege of lunching with Professor Alonzo E. Taylor in Philadelphia, when I received at first hand information regarding some of his important observations in Germany on the dietetic habits of the German civilian population. While there was no quantitative measurement of the food intake of these people, the fact appeared to be established without doubt that the Germans were subsisting upon a very low calorie intake and that this had endured for so long a time since the beginning of the war that it seemed highly probable that the former liberal body reserves no longer supplemented the diet. As a result of this conference a previously formed plan was crystallized into definite action. After conference with my colleagues at the Nutrition Laboratory, an extensive research upon the influence of a prolonged reduction in diet on a group of men was outlined. Obviously much profit was derived from the criticisms of the historic research of Professor Chittenden with his group of soldiers. Professor Chittenden's problem dealt mainly with the nitrogen intake and output, but when the energy of the diet comes into discussion, it is clear that the dietetic control must be even more rigid and one must, in the last analysis, be wholly dependent upon the personal integrity and veracity of the subjects. If a person ate more protein than was allowed, this would show in the urine. A person could eat considerably more calories than actually allowed and yet no direct chemical control could be secured.

Through the kind offices of Professors J. H. McCurdy and

Elmer Berry, of the International Y. M. C. A. College at Springfield, Massachusetts, both unusually interested in metabolism problems, arrangements were made to select twelve men out of a group of volunteers from the student body. The men entered heartily into the spirit of the whole research and readily consented to all the strict requirements of the test. It is a great pleasure to record that during the four months of experimenting there was not the slightest indication of any of these men wittingly or unwittingly violating even the strictest regulations of the research. The honor system obtains at the College; the men realized that they were in a position to do the nation a great service and with the fidelity, enthusiasm, and high ethical spirit exhibited by the whole student body, these men went through the arduous four months without a serious complaint.

The general plan was to curtail the diet sufficiently to reduce the weight approximately 10 per cent. This could have been done by a complete withdrawal of food for about 14 or 15 days. It was recognized that these men were, first, college students with obligations for educational advancement and, second, volunteers for scientific research. A complete fast for 14 days would, in all probability, have caused most of them considerable discomfort, if not distress. The alternative was to curtail the dietetic intake so that the weight loss would take place, not in 14 days, but in 4 to 6 weeks. This was done by serving the men approximately one half to two thirds of the caloric requirements prior to the dietetic control, making absolutely no change in the kinds of foods eaten. The men were cautioned not to lessen their mental or physical activities. Obviously if the activity of a group of men were lessened as, for instance, by putting them to bed, to use an extreme illustration, their dietetic requirements would be very much less. Suffice it to say that these men carried out all the requirements of collegiate activity, both physical and intellectual, throughout the entire period. As soon as the reduction in weight had reached 10 per cent. or thereabouts, the calories in the intake were increased to such an extent as to hold the weight at a constant level. The number of calories required to hold this weight constant over a considerable period of time could be taken as a fair representation of the actual caloric requirement for this group of men.

At the start we were confronted with the possibility of a seasonal variation. Thus, if one took a group of twelve active Y. M. C. A. students, at the end of a summer vacation, fresh from summer camps with their outdoor activities, and placed them in academic halls with restricted hours, artificial illumination, and curtailed physical activity, it is conceivable that there would be a normal retardation of metabolism in the later fall months. To insure a suitable base line, therefore, a second group of twelve men from the large number of volunteers originally presenting themselves were selected to act as a control squad. These men were in every particular studied with the same degree of care as Squad A, except that there was no dietetic control.

While body-weight can be taken as an approximate index of the metabolic level, further checks were absolutely necessary to rule out the inevitable difference in muscular activity that would be found with groups of individuals, even when they were subsisting under the same collegiate conditions. The gaseous metabolism was therefore measured practically every morning for each one of the first squad. These measurements were made by collecting the expired air and analyzing it. From the amounts of oxygen consumed and carbon dioxide produced the basal heat output could be computed by indirect calorimetry, thus furnishing the second index of metabolic level. The pulse rate was recorded simultaneously every morning. Every other Saturday night the entire group of men were taken to Boston and placed inside a large respiration chamber, where they could sleep comfortably. The carbon-dioxide excretion of the twelve men was thus determined simultaneously during deep sleep. This furnished a third criterion for judging the metabolic level.

The control squad showed no seasonal variation and their basal metabolism, as measured in the large respiration chamber in Boston, was found to be absolutely identical with that of the first group of twelve men prior to the restriction in diet. To check the important findings with the first squad during the early period of the investigation, the second squad was later placed upon a very restricted diet for a period of three weeks, the diet given being less than one half of their normal requirements.

For both squads, when on diet, the food for each day was care-

fully weighed, sampled, and analyzed for the individual men. It is thus possible for us to measure the complete intake of protein and calories. The urine was collected throughout the entire time, and the feces at frequent intervals. It is a tribute to the painstaking and conscientious coöperation of these men that throughout the entire period of four months the urine was rarely lost. We thus have complete data for striking a balance between the nitrogen in the food and the nitrogen in urine and feces.

Advantage was taken of each bi-weekly visit of the separate squads to the Laboratory in Boston to put them through 17 psychophysiological tests. Although it was rather difficult to secure much evidence of introspection without the danger of suggestion, careful records of all the relevant observations on introspection were made.

The most important scientific findings may be summed up as follows:

1. A gradual reduction in weight to a point 12 per cent. below the initial weight took place during a period of from 3 to 10 weeks, with low calories and a moderate amount of protein in the food intake. The normal demand of the men prior to the dietetic alteration ranged from 3,200 to 3,600 net calories. One squad of 12 men subsisted for three weeks on 1,400 net calories without special disturbance.

2. After the loss in weight of 12 per cent. had been reached, the net calories required to maintain this weight averaged about 2,300, or approximately one third less than the original amount required.

3. At the end of the reduction in weight the actual heat output during the hours of sleep, as computed by indirect calorimetry, was approximately one fourth less than normal, thus giving a rough confirmation of the lowered number of calories found by actual measurement of the food intake. That there was no pronounced seasonal variation in metabolism was shown by the uniformity of the metabolic level of the control squad (Squad B).

4. The heat output by indirect calorimetry per kilogram of body-weight and per square meter of body surface was essentially 18 per cent. lower than at the beginning of the study.

5. Throughout the period of loss in weight and for some time subsequent thereto, there was a pronounced loss of body nitrogen.

In round numbers these men each lost approximately 150 grams of nitrogen. There is an intimate relationship between this "surplus nitrogen" and the metabolic level. Removing the "surplus nitrogen," we believe, distinctly lowers the stimulus to cellular activity.

6. The urine nitrogen per day at the maintenance diet of 2,300 net calories was about 9 grams. The control group of 12 men, living substantially the same life and eating in the same dining room, but with unrestricted diet, showed a nitrogen output of 16 or 17 grams per day.

7. The pulse rate was astonishingly lowered. Many of the men showed morning pulse rates as low as 33 and daily counts of 32, 31, and 30 were obtained; at least one subject gave six definite counts on one morning of 29.

8. The blood pressure, both systolic and diastolic, was distinctly lowered.

9. The skin temperature, as measured on the surface of the hands and forehead, was, with some subjects, considerably lower than normal. With most of the men normal temperatures prevailed.

10. The rectal temperature was practically normal.

My colleague, Dr. Walter R. Miles, found as a result of numerous tests of the neuro-muscular processes that there was no striking change as a result of the reduced diet. There was a very slight falling off in the strength tests with the hand dynamometer.

As one of the best indices of muscular performance my associate, Dr. H. Monmouth Smith, measured the energy required by each man to walk 1 mile in about 20 minutes. With a reduced diet, the requirement was found to be lower with all the men than with a normal diet, this being due, in part, to the fact that the reduced weight meant a lower weight to transport. In other words, these men walked a mile with noticeably less energy consumption than a man not subsisting on a reduced diet.

The subjective impressions were almost uniform that the muscles in the thigh were distinctly weakened. The men complained of difficulty in walking upstairs, but our personal observations go a long way toward refuting this, for all the men seemed able to go upstairs two steps at a jump on several occasions. On February 1, 1918, at Springfield, after 4 months on diet, eleven of the diet

squad were pitted against eleven men from the college body in an arm-holding contest for endurance. The arms were held extended, palms down, at the level of the shoulder. The number of men falling out were practically the same in both squads; as a matter of fact, 7 in the diet squad and 8 in the uncontrolled squad held their arms out for one full hour.

Two of the men had chronic bad noses. One was operated upon during the test and the other should have been. Aside from these two, the prevalence of colds during the period was about the same as with the other college students. During the study three men underwent ether narcosis for operations (on nose, foot, and hemorrhoids) and made rapid recoveries. One man at the lowest period of weight contracted what was diagnosed by three physicians as typhoid fever, although the final course of the disease seemed to leave the diagnosis somewhat in doubt. He ran through a very high fever, and was critically ill for some time, but has made a complete convalescence and recovery and has returned to college.

The most noticeable discomfort experienced by the subjects was a feeling of cold, which it is only fair to say might be due in large part to the severity of the past winter. In general, notwithstanding the very great reduction in the metabolism, which we believe was due to the removal from the body of the stimulus to cellular activity of approximately 150 grams of "surplus nitrogen," the whole period of lowered food intake had no untoward effect upon the physical or mental activities, and the men were able to continue successfully their college duties.

When the second squad was put upon a restricted diet, the picture exhibited by the first squad was strikingly duplicated in all details, although, as the loss in weight was obviously not so great with the second squad (6 per cent. as compared with 12 per cent.) the phenomena were quantitatively somewhat less emphasized.

At the conclusion of the entire research the men presented an appearance not unlike the average college student; it would have been difficult to pick them out from the rest of the college body on the campus. On close inspection the members of the diet squad would perhaps have appeared somewhat emaciated, particularly in the face, but they were performing their duties as college students,

both physically and intellectually, with no obvious reduction in stamina. No words can express their exact condition at the end of these tests so clearly as a short section of motion-picture film, showing the general agility, spirit, and physical ability of these men.

The great objection to making practical deductions from laboratory experiments is usually that such researches are carried out on the lower animals, or if men are studied but one or at the most two men are used. With a group of twenty-five men, such as was studied in this research, one is justified, if ever, in drawing deductions or making recommendations. In addition to the fact that we have experimental evidence based upon twenty-five men from which to draw conclusions, we have also the fact that this is a period of stress, a period of innovation, a period for trial, for experimentation, for "taking chances," if you will. These combined factors are based, first, upon the large human experience of enforced diet restriction in Germany, second, upon the psychological set of the patriot and, third, upon the moral obligation laid upon us all to contribute to the vast project of food conservation. We cannot then be charged with faddism or irrational propaganda if we are led to make certain definite recommendations—recommendations that admittedly we would never make in peace times and that admittedly may have serious faults. These recommendations are primarily a war measure. In time of peace and plenty, the physician would rightly caution against an undue adjustment of the diet or fundamental alteration in dietetic habits. Still, when millions of our allies and hundreds of thousands of our own people are jeopardizing their very existence, it is not the time to talk about the possible dangers of moderate or even considerable changes in diet. With a large number of individuals it may be of real psychological benefit to realize that they may, by personal diet restrictions, introduce an element of hazard into their lives, slight though it may be. No one could look at those vigorous young men, carrying out their college work, examinations, and physical activities in competition with their classmates, and not be impressed by the fact that the danger, if any exist, must be extremely distant.

As an index to the rather remote probability of danger one should be reminded that the modern treatment of severe diabetes is

essentially founded upon a lowering of the basal metabolism. Dr. Allen's diabetics, practically wrested from the jaws of death, present a remarkable picture. The curtailment in diet, with the low stimulus to cellular activity, has certainly in their case been a lifesaving benefit.

A research of this kind offers almost unlimited field for speculation not only in pure physiology but likewise in its practical applications to everyday life. We believe it was made with a sufficient number of men to rule out the personal equation. Indeed, the individual picture presented by each man is strikingly uniform with the general picture presented of the group. There are no exceptions.

I find myself in a novel situation as a public advocate of far-reaching dietetic alterations. Recalling my earlier objections to Professor Chittenden's inferences from his experiments, I realize that, although abstract science and propaganda are more or less incompatible, in time of stress old beliefs may well be challenged, earlier concepts discarded, and conservatism permitted to exercise a less restraining influence; hence a public avowal of change in point of view and an admission of the errors of earlier judgment are not only desirable but absolutely necessary. While still maintaining that the published records of Professor Chittenden's experiments left the desirability of a propaganda for lower protein and energy open to serious fundamental criticism, I am now convinced that his data on protein intake justified many of his public statements and recommendations. His conjectures regarding calorie needs seem in no small part substantiated by the results of this new research.

Although some of our men were under twenty-one years of age, the data obtained in our experiments have no bearing on the period of growth; the diet of the growing child should under no circumstances be reduced. Neither are the results applicable to the conditions of severe muscular work as, for example, in the army. They may, however, legitimately suggest practices for patriotic civilians not performing severe muscular work; that these standards represent the optimum needs for peace times requires further evidence for substantiation. It is quite clear that a civilian body of men could readily withstand a siege on half rations without difficulty

for several months, and since danger seems remote, that reduced rations for all adult civilians may be justifiable as a war measure for a relatively long period of months. Professor Chittenden's conclusions from his experiments that a low-protein diet is practicable seem fully substantiated; this expensive source of food material may thus be materially lowered. The calories may also, without doubt, be lowered. Indeed, it may become a serious question as to whether a patriot should be permitted in times of stress to carry excess body-weight, for the expense of carrying it around calls for calories that other people need. The excess weight is *prima facie* evidence that he is living at the highest metabolic level, higher than he needs by approximately 25 per cent., and there is no doubt that the excess weight contributes to shorten life.

Certain practical points in connection with a reduction in diet are important. Difficulties in the shape of tendency to constipation can be easily controlled by the use of bran, as was done in our study. Bran also provides a certain amount of bulk which helps materially in producing a feeling of satiety. It is quite clear that variation in diet is absolutely essential. If a person craves a certain article of food, he may eat it, but stick religiously to the "half portion." The presence of an unlimited food supply on the table makes self denial harder. Of special significance is the importance of not eating between meals and of omitting the eating of extras in the form of candy, peanuts, and minor luxuries. It has surprised us to find how large a proportion of the total diet is made up of these extras. Captain Gephart in his study of the food intake of St. Paul's School, Concord, New Hampshire, found that out of a total daily intake of 5,000 calories per boy, 647 calories were derived from extras in the form of sweet chocolate, candy, coffee buns, etc. With our control squad at Springfield when on normal diet, approximately 4,000 calories were consumed daily by each individual. Of this amount about 400 calories were obtained from extras not served at the table.

This is no time for the epicure. Every person should be under, rather than over weight and it should be popular not to be fat. Today every woman as well as man, should make it a special mission to see to the physical condition and not carry around excess

fat or live upon an abnormally high metabolic level. By this means a great saving of food in this country can be effected to the positive advantage of health. It is more than probable that with reduction in flesh, the physical appearance will be somewhat less satisfactory, for admittedly the face may appear somewhat drawn. On the other hand, it is absolutely proved that excess weight is distinctly disadvantageous to health. People especially over thirty years of age who are over weight are notoriously bad insurance risks. Even those over weights without demonstrated organic change in early or middle life show very high death rates. Nobody should be over weight; most people should be somewhat under rather than over weight. If, when the war is ended, plenty is established and the need for restriction is removed, one wishes to go back to the former metabolic level, the way is very clear. The palate will lead to this way very readily. The purse may permit indulgence but the health may really be better for a moderate reduction.

Professors Chittenden and Lusk are now in Europe with the essentials of this research in typewritten form in their hands. Certain recommendations may well be made to our Allies and, indeed, to our own non-combatants. We, who are far from the misery, trials, and torments of the battlefield, are asked to restrict our diet intake, not only qualitatively (which Mr. Hoover and his associates have so wisely educated us to do), but quantitatively. It has been a fact, and a noticeable fact, that our most intelligent and best American men and women have been eager and anxious to do all they could, even at this distance, for the sake of the great cause. In this land of plenty it is highly improbable that positive measures calling for actual caloric restrictions will have to be passed, although this is by no means an impossibility. Here, as with all conservation measures, the volunteer is the first to take action. Let no one (particularly if he be overweight) complacently say that he has done his share until some positive action for food restriction has been taken. Fortunately no special chemical analyses, no calorimetric devices, no physiological measurements are essential for the control of this factor. One has but to lower the body-weight gradually 10 per cent. and adjust the food eaten to hold it at this level. The reduction in weight should cover a period of probably two to three

months. It could be done in a considerably shorter time. When the weight is once lowered, and the caloric intake adjusted to holding the weight at that level, the patriot may feel assured that he or she is really making some positive contribution toward food conservation and making it possible to send liberally to our allies and to our own men much-needed supplies.

I cannot feel that an alteration in the army diet is justifiable at present. It is bad policy "to swap horses in the middle of the stream." The fighting unit may well be exempted from innovations but let the civilian population give this whole project a thorough, honest test, recognizing that while there may be, in certain cases, an element of hazard and in many cases an element of discomfort, the possibilities for danger in accomplishing a weight reduction of 10 per cent. are negligible. The calories thereby saved are by no means negligible, but with the sum total of our population would feed an enormous army.